Hydrogen Production from Waste Stream Urea Recovery

By Carl Feickert

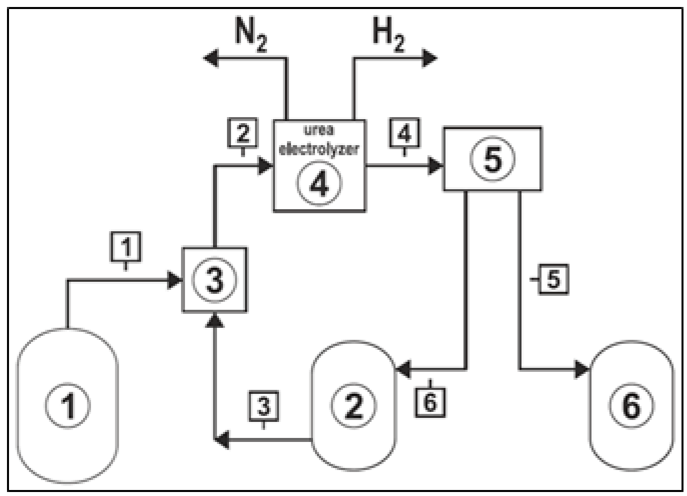
Research at the U.S. Army Engineer Research and Development Center is developing a process to harnesses the properties of a free, plentiful, naturally occurring substance – urine – and convert it to hydrogen that can power a fuel cell. ERDC's Construction Engineering Research Laboratory has joined with a research team at Ohio University, Athens, Ohio, to develop this pioneering solution for providing hydrogen fuel as part of the Army's goal to drastically reduce carbon-based energy fuels and their associated greenhouse gases. In addition, the process could potentially be used at forward operating bases to generate electricity with a locally available resource.

The Department of Defense fuel cell program is based at CERL, which has conducted numerous technology demonstrations at sites around the world. Hydrogen gas is the fuel of choice for fuel cells as it is non-polluting and has no direct GHG footprint. The research is attempting to minimize the *total* energy production requirements and thus economically produce hydrogen gas through the electrical transformation of liquid urea into hydrogen.

This process involves the removal and usage of the common pollutants, ammonia (NH_3) and urea, from the local environment through their recovery from the waste streams of waterless urinals" and their direct electrochemical decomposition into fuel cell quality hydrogen gas for use in non-polluting electrical production. The process starts with ammonia and urea, common waste products found in the excretions of all higher order vertebrates, and proceeds through the use of specially designed catalytic materials and geometries for use in a specially designed electrolyses cell. The pathways for the electro-decomposition of these chemicals are well understood, and make for the electrochemical reduction of urea into hydrogen, nitrogen and water using renewable energy sources and the low energy process embodied in this research.

The system under investigation is depicted in the diagram. Collected urea and/or urine (stream 1) is adjusted to a pH of 11 by using potassium hydroxide (stream 3). The adjusted influent (stream 2) enters the urea electrolyzer, producing pure N_2 and pure H_2. The water leaving the electrolyzer (stream 4) contains some of the electrolyte, which is recovered through reverse osmosis and sent back into the electrolyte recovery tank (stream 6). The effluent leaving unit 5 is clean and is stored to enable the research team to evaluate uses for the reclaimed water.

The current version of Urine Electrolyzer (UE) has been demonstrated at 10 watts of power consumption and has further been shown to be linearly scalable. The hydrogen produced from the UE has been used in a proton exchange membrane fuel cell and provided stable performance. The next test will involve the design and fabrication of a 1-kilowatt unit capable of prolonged operation to determine continuity of flow rates, and cell longevity when integrated with a traditional PEM fuel cell. Waterless urinals are a successfully demonstrated commercial technology. And since the energy input from the urea has no costs to the system, laboratory experience indicates that the combined system can deliver ~50% more net electrical power than what is required to perform the electrical decomposition of the urea.



Schematic of the proposed system for the removal of urea from waste with hydrogen co-generation. The following parts constitute the system: 1. Waterless urinal waste storage tank (urine and blue seal), 2. Electrolyte storage tank, 3. pH adjustment unit (operational pH=11), 4. urea electrolyzer, 5. Electrolyte recovery unit (reverse osmosis), 6. Reclaimed water storage tank

This technology could have a number of direct benefits for the Army. It could be used to supply back-up power for training facilities and for base camps, under the "Silent Camp" initiative, in which power is supplied via low-noise, low-impact ("green") methods instead of noisy and inefficient diesel generators. The hydrogen produced through the processes can be combined with a fuel cell to provide power

– thus offering a safe, convenient alternative to the generators. It also has potential for non-military applications (e.g., agricultural wastewater, municipal wastewater, etc). Other advantages of this electro-decomposition process include: (1) the fuel cell does not require hydrogen storage, but is capable of providing a continuous hydrogen flow stream; (2) ammonia and urea are less flammable and safer to transport than hydrogen; (3) the use of liquid ammonia or urea significantly reduces the volume of storage when compared to ammonia in the gas phase, and is more energetically favored over water hydrolyses; (4) only environmental friendly byproducts are generated (N_2) in the decomposition, and (5) the cell operates silently at a relatively low temperature (maximum 70° C) with corresponding reduced sonic and thermal signatures.

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